

# Experimental Study on Replacement of Fine Aggregate by Used Foundry Dust in Concrete

K. Gomathi<sup>1</sup>, J. Velvizhi<sup>2</sup>, V. Thirumoorthy<sup>3</sup> And M. Saravanan<sup>4</sup>

UG student, Department of Civil Engineering, P. B. College of Engineering, Chennai, India<sup>123</sup>

Assistant Professor, Department of Civil Engineering, P. B. College of Engineering, Chennai, India<sup>4</sup>

**ABSTRACT:** An acute shortage of river sand which is generally used as a fine aggregate in concrete has been affecting the construction sector. The scarcity has led to the skyrocketing price of sand, escalating construction costs. The situation has dashed the dreams of many in the lower and middle income groups to own a house. There were studies about the depletion of river sand and the need for scientific management and exploitation of the available resource. Following the shortage of river sand, some research institutions are searching alternatives that can be used for construction. Ferrous and non ferrous metal casting industries produce several million tonnes of byproduct in the world. In India, approximately 2 million tonnes of waste foundry sand is produced yearly. WFS is a major byproduct of metal casting industry and successfully used as a land filling material for many years. In an effort to use the WFS in large volume, research is being carried out for its possible large scale utilization in making concrete as partial replacement of fine aggregate. Foundry sand consists primarily of silica sand, coated with a thin film of burnt carbon, residual binder (bentonite, sea coal, resins) and dust. Foundry sand can be used in concrete to improve its strength and other durability factors. Foundry Sand can be used as a partial replacement of fine aggregates or total replacement of fine aggregate and as supplementary addition to achieve different properties of concrete. This experimental investigation was performed to evaluate the strength properties of concrete mixtures, in which river sand was partially replaced with Waste Foundry Sand by weight. Compression test was carried out at the age of 28 days of curing. Split tensile test was performed at the age of 28 days. Flexural strength was tested at 28 days of curing. Test results indicate an increase in compressive strength of plain concrete by inclusion of WFS as a partial replacement of fine aggregate. The maximum strength was achieved at 40% replacement, after which there was loss in compressive strength, split tensile strength and Flexural strength decreased.

**KEYWORDS:** *Foundry dust, Superplasticizer, compressive strength, split tensile strength, flexural strength*

## I. INTRODUCTION

Throughout the world, concrete is being widely used for the construction of most of the buildings, bridges, etc. Hence, it has been properly labeled as the backbone to the infrastructure development of a nation. Sustainable construction has become an interest in the engineering community and several standards have been developed to assess the environmental impact of new construction projects. Researches have shown that it is possible to use recycled materials to replace some of the traditional mixture components in concrete products and produce a more sustainable building material. One common material that can be recycled and have the possibility of use in concrete applications is used foundry dust. Eggshell waste falls within the category of food waste, which is materials from the preparation of foods and drinks, if subjected to adequate scrutiny, and they could be suitable alternative material for construction. Concrete is a man made building material that looks like stone. The word concrete is derived from the Latin *concretus*, meaning to grow together. Concrete is a composite material composed of coarse granular material (the aggregate or filler) embedded in a hard matrix of material (the cement or binder) that fills the space among the aggregate particles and glues them together. Alternatively, we can say that concrete is a composite material that consists essentially of a binding medium in which are embedded particles or fragments of aggregates. The simplest definition of concrete can

**International Journal of Innovative Research in Science, Engineering and Technology***An ISO 3297: 2007 Certified Organization**Volume 7, Special Issue 5, April 2018***1<sup>st</sup> International Conference on Recent Innovation in Civil Engineering and Management (ICRICEM '18)****22<sup>nd</sup> March 2018****Organized by****Department of Civil Engineering & MBA, Loyola Institute of Technology, Chennai, Tamilnadu, India**

be written as; concrete=filler + binder. Concrete can be used for all standard buildings both single storey and multistorey and for containment and retaining structures and bridges. In the usage of concrete, the designer should be knowledgeable of the strength and weaknesses of concrete. In the production of good concrete, fine and coarse aggregates combined in a correct ratio or proportion are bonded together by a cementitious material (usually Portland cement) to form a harden matrix concrete.

**II.MATERIAL PROPERTIES****2.1 Materials**

In the design of high performance concrete the selection of proper ingredients evaluating their properties and understanding the interaction between different materials plays a major role in performance of the concrete. The ingredients used are cement, Foundry sand, natural sand, coarse aggregate, super plasticizer. The performance requirements of concrete enhancements of the following

1. Ease of placement and compaction by no segregation.
2. Long term mechanical properties.
3. Early strength.
4. Toughness.
5. Volume stability.
6. Long term durability properties.
7. Longer service life.
8. The efficiency of high performance concrete is improved by proper selection controlling and proportioning the ingredients of high performance concrete.

**2.2 Foundry Sand**

Foundry sand consists primarily of clean, uniformly sized, high-quality silica sand or lake sand that is bonded to form molds for ferrous(iron and steel) and nonferrous (copper, aluminium, brass) metal castings. Although these sands are clean prior to use, after casting they may contain ferrous (iron and steel) industries account for approximately 95 percent of foundry sand used for castings. The automotive industry and its parts suppliers are the major generators of foundry sand.

The most common casting process used in the foundry industry is the sand cast system. Virtually all sand cast molds for ferrous castings are of the green sand type. Green sand consists of high-quality silica sand, about 10% bentonite clay (as the binder), 2 to 5% water and about sea coal (a carbonaceous mold additive to improve casting finish). The type of metal being cast determines which additives and what gradation of sand is used. The green sand used in the process constitutes upwards of 90 percent of the molding materials used.

In addition to green sand molds, chemically bonded sand cast systems are also used. These systems involve the use of one or more organic binders(usually proprietary) in conjunction with catalysts and different hardening/setting procedures. Foundry sand makes up about 97% of this mixture. Chemically bonded systems are most often used for "cores" (used to produce cavities that are not practical to produce by normal molding operations) and for molds for nonferrous castings. The annual generation of foundry waste (including dust and spent foundry sand) in the United States is believed to range from 9 to 13.6 million metric tons (10 to 15 million tons). Typically, about 1 ton of foundry sand is required for each ton of iron or steel casting produced. The properties of Foundry sand as shown in Table 2.1

**Table 2.1: Properties of Foundry sand**

S.No	Physical properties	Result
1.	Specific gravity	2.55
2.	Physical form	Powder
3.	Size (Micron)	600micron
4.	Color	Black



#### 2.4 Super plasticizers

Super plasticizer named Conplast SP430 is used. It helps in dispersing cement particles, and they can reduce mixing water requirements by up to 30%, thereby increasing the concrete compressive strength. The Sulphonated Naphthalene Formaldehyde based super plasticizer (Conplast Super Plasticizer – SP 430) . The properties of superplasticizer are shown in Table 2.2.

**Table 2.2 Properties of super plasticizer**

S.NO	PhysicalProperty	Value
<b>I.</b>	Solid content	42%
<b>II.</b>	Specific gravity	1.22



**Fig. 2.2 Super plasticizer**

### III. MIX DESIGN

#### 3.1 GENERAL

The process of selection suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required strength and workability as economically as possible, is termed the concrete mix design. The proportioning of ingredient of concrete is governed by the required performance of concrete in two states, namely the plastic and the hardened states. If the plastic concrete is not workable, it cannot be properly placed and compacted. The property of workability therefore becomes of vital importance.

#### 3.2 MIX PROPORTIONS

Cement	= 350 kg/m <sup>3</sup>
Water	= 140 kg/m <sup>3</sup>
Fine aggregate	= 896 kg/m <sup>3</sup>
Coarse aggregate	= 1140kg/m <sup>3</sup>
Chemical admixture	= 7 kg/m <sup>3</sup>

### IV. EXPERIMENTAL PROGRAM

#### 4.1 MECHANICAL PROPERTIES

##### 4.1.1 Compression Test (Ref: IS: 516-1959)

Compression test is the most common test conducted on hardened concrete, partly because it is an easy test to perform, and partly because most of the desirable characteristics properties of concrete are qualitatively related to its

compressive strength. Compressive strengths were attained as a result of the compressive tests conducted on the cube specimens of size 150mm x 150mm x 150mm . Cube was placed on the platform of the compression testing machine. The load was applied gradually till the concrete cubes get failed. The specimens are subjected to compressive loads in compression testing machine as per IS: 516-1969 and the crushing load is noted which gives the compressive strength of that cube. The compressive strength is the ratio of crushing load to the surface area of the specimens expressed in  $N/mm^2$ . Similarly the compression strength values of all the cubes are found.

Mix proportions	Cement $kg/m^3$	Fine Aggregate $kg/m^3$	Foundry Sand $kg/m^3$	Coarse Aggregate $kg/m^3$	Water $kg/m^3$	Chemical Admixture $kg/m^3$
Mix 1(0%)	350	896	0	1140	140	7
Mix 2(15%)	350	760	136	1140	140	7
Mix 3(30%)	350	626	270	1140	140	7



Fig 4.1 Test Set up for Compressive Strength Test

#### 4.1.2 Flexure Test (Ref: IS: 516-1959)

The flexural strength represents the highest stress experienced within the material at its moment of rupture. It is measured in terms of stress, here given the symbol  $f_{cr}$ . The flexural strengths of the respective specimens have been obtained from the flexural tests performed on the prism specimens of size 150mm x 150mm x 700mm. The flexural strength are tested using a one point loading frame machine as per standard as shown in figure 5.2.



**Fig 4.2 Test Set Up for Flexural Strength**

The modulus of rupture can be determined by using the formula given below

$$f_{cr} = (P_{max} \times l) / bh^2$$

where,

$f_{cr}$  = Flexural strength  
 $P_{max}$  = maximum load in (N) kg.  
 $b$  = width of the prism in mm  
 $h$  = depth of the prism in mm  
 $l$  = span of the prism in mm

The loading must be applied centrally and without subjecting the specimen to any tensional stresses and restraints. The axis of the specimen shall be carefully aligned with the axis of the loading device. The load shall be applied without any shock and increasing continuously at specified rate.

#### **4.1.3 Split tensile strength Test (Ref: IS: 5816-1999)**

Split tensile strength of concrete is usually found by testing plain concrete cylinders. Cylinders of size 150mm x 300 mm were casting using M25 grade concrete. Specimens with Conventional Concrete and SCC of two different percentages were casted. During casting the conventional concrete cubes were manually compacted using tamping rods. After 24hours, the specimens were removed from the mould and subjected to water curing for 7, 28 days. After curing, the specimens were tested for compressive strength as per IS: 5816-1999 using a calibrated compression testing machine of 2000KN capacity.

Two packing strips of plywood 3mm thick were provided between the specimen one at top and another at bottom. The specimen was placed on the plywood strip and aligned so that, the central horizontal axis of the specimen is exactly perpendicular to the load applying axis. The second plywood strip was placed length wise on the cylinder and the top platen was brought down till it touched the plywood. The load was applied without shock and increased continuously until the resistances of the specimen to the increasing load broke down and no greater load can be sustained.



$$\text{Tensile strength of concrete } f_t = \frac{P}{A}$$

Where ,

$$P = \text{Maximum load in N applied to the specimen}$$

$$L = \text{Measured length in cm of the specimen}$$

$$D = \text{Measured diameter in cm of the specimen}$$



**Fig 5.3 Test set up for split tensile test**

## V.RESULTS AND DISCUSSION

### 5.1 GENERAL

This chapter deals with the results obtained from the various experiments conducted to access mechanical properties. The aim of the study is to determine the compressive strength, flexural strength and split tensile strength. so the results of test specimens are presented. The discussion on the results also presented in this chapter.

### 5.2 MECHANICAL PROPERTIES

The mechanical properties of concrete such as compressive strength, flexural strength and split tensile strength are determined from the standard experiments. They are as follows.

#### 5.2.1 Compressive Strength

The compressive strength of replacement of foundry sand is arrived. The compressive strength value for replacement of Foundry sand Table 5.1 Shows compression test results.

**Table 5.1: Compressive Strength of Cubes with Partial Replacement of Foundry sand**

Curing days	Compressive Strength, N/mm <sup>2</sup>		
	Mix 1(0%)	Mix 2(15%)	Mix 3(30%)
7 days	26.26	30.21	32.44
28 days	47.73	51.41	56.44

### 5.2.2 FLEXURAL STRENGTH

The flexural strength of replacement of metakaolin is arrived.. Table 5.2 shows flexural strength test results

**Table 5.2: Flexural Strength of beams with Partial Replacement of Foundry sand**

Curing days	Flexural Strength, N/mm <sup>2</sup>		
	Mix 1(0%)	Mix 2(15%)	Mix 3(30%)
28 days	6.3	6.88	7.56

### 5.2.3 SPLIT TENSILE STRENGTH

The variation of split tensile strength at the age of 28 days with different percentage of metakaolin, and fly ash from the test results, it was observed that the maximum split tensile strength was obtained for mix of 15% replacement of fly ash by metakaolin. Table 5.3 flexural strength test results

**Table 5.3: split tensile strength of Cylinder with Partial Replacement of Foundry sand**

Curing days	Split Tensile strength, N/mm <sup>2</sup>		
	Mix 1(0%)	Mix 2(15%)	Mix 3(30%)
28 days	4.05	4.47	5



**International Journal of Innovative Research in Science, Engineering and Technology**

An ISO 3297: 2007 Certified Organization

Volume 7, Special Issue 5, April 2018

1<sup>st</sup> International Conference on Recent Innovation in Civil Engineering and Management (ICRICEM '18)

22<sup>nd</sup> March 2018

Organized by

Department of Civil Engineering & MBA, Loyola Institute of Technology, Chennai, Tamilnadu, India

**VI. CONCLUSION**

The compressive strength of 7 days for conventional concrete, mix 1, mix 2 increases gradually. Hence we concluded that the foundry dust gives the additional strength to the concrete. Replacement of fine aggregate with waste foundry sand showed increase in the compressive strength of plain concrete of grade M40. For concrete mix at 15% & 30% replacement of fine aggregate, strength of 51.41N/mm<sup>2</sup> & 56.15N/mm<sup>2</sup> was achieved respectively at 28 days which is more than the target strength. It is more than 7% and 15% from the target strength for 15% and 30% replacement of fine aggregate respectively. The water cement ratio of 0.4 by experience achieves the expected strength of the concrete. From the obtained results it can be concluded that concrete obtaining waste foundry sand upto 30% can be efficiently used for structural applications.

**REFERENCES**

1. **B.J. Lee, G. Prabhu, J.W. Bang, J.H. Bang, J.H. Hyun, Y.Y. Kim**, "Mechanical and durability properties of concrete made with used foundry sand as fine aggregate" *Advances in materials science and Engineering*, Vol.3, Issue 4, January 2015.
2. **J.M. Khatib, B.A. Herki, S. Kenai**, "Capillarity of concrete incorporating waste foundry sand", *Construction and building materials*, Vol. 47, pp.867-871, march 2013.
3. **J.M. Khatib, S. Baig, A. Bougra and C. Booth**, "Foundry sand utilization in concrete production", *Construction and Building Materials*, Vol.4, pp.456-462, January 2012.
4. **R. Siddique, G. Sani, F. Tittarelli**, "Used Foundry sand in cement mortars and concrete production", *The open Waste management journal*, Vol.3, pp.18-25, April 2010.
5. **T.R. Naik, V.M. Patel, D.M. Parikh, M.P. Tharaniyil**, "Utilization of used foundry sand in concrete", *Journal of Material in Civil Engineering*, Vol.6, No.2, May 1992.
6. **Concrete technology by M.S. Shetty**.
7. **IS 10262**, "Concrete Mix proportioning-Guidelines, Bureau of India Standards, New Delhi, 2013.
8. **IS 4031**, "Methods of physical tests for hydraulic cement, Bureau of Indian Standards, New Delhi, 1999.
9. **IS 383-1970**, "Coarse and Fine aggregates from Natural Sources of Concrete, "Bureau of Indian Standards, New Delhi, 2002.
10. **IS 9103-1999**, "Concrete Admixtures-Specification, "Bureau of Indian Standards, New Delhi, reaffirmed 2004.
11. **IS 516-1959**, "Methods of tests for strength of Concrete", Bureau of Indian Standards, New Delhi, reaffirmed 2004.
12. **IS 5816-1999**, "Splitting Tensile Strength of Concrete-Method of Test, "Bureau of Indian Standards, New Delhi, reaffirmed 2004.
13. **ASTM C490**, "Standard practice for use of Apparatus for the determination of Length change of Hardened Cement Paste, Mortar and concrete, 2007.